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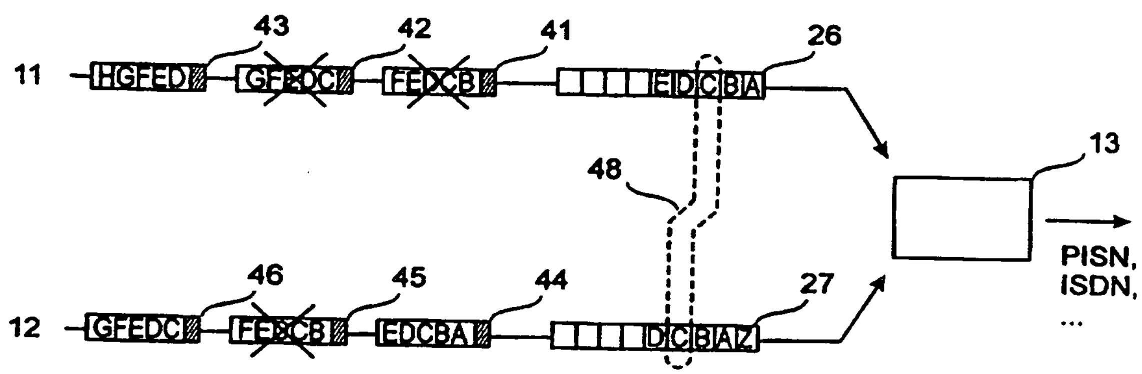

(57) Abstract

A method and an equipment for transferring a transmission signal of a digital mobile communication system as packets (41-46) of a packet network, e.g. the ATM network, the packets comprising a header and a payload. Radio stations (11, 12) place traffic frames (A-H) and/or parts thereof in the payloads of the packets, and the packets are sent to a destination. Previous traffic frames or parts thereof of the same connection are placed in the payload of the packets (41-46) in addition to the latest traffic frame (A-H) formed until the payload of the packet (41-46) is essentially filled. At a combination point (13) the traffic frames (A-H) included in the same packet (41-46) are separated from each other and stored in a buffer memory (26, 27) unless a corresponding traffic frame (A-H) sent by the same radio station (11, 12) is already stored in the buffer memory (26, 27). Even if the packet network lost some packets (41, 42, 45), each buffer (26, 27) comprises an uninterrupted sequence of traffic frames in spite of the loss of packets, and the packets lost by the network do not have to be retransmitted. If parameters representing the quality of the connection are placed in the part of the payload of a packet (41-46) not filled with traffic frames (A-H), the connection point (13) may choose (48) the best traffic frame (A-H) relayed across different branches.

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UTILIZING ATM CELLS IN MOBILE NETWORK

BACKGROUND OF THE INVENTION

The invention relates to a method and an equipment for relaying speech frames of a mobile communication system as packets of a packet network, particularly the ATM network. The invention will be described in connection with the ATM network, but can be applied to other packet networks, too.

The invention is described in connection with speech processing and speech frames, but the same technique may also be applied to transferring music and video signals. It is common to these signals that signal samples have to be led to a decoder isochronously, i.e. at intervals essentially equal to those used when generating the samples in a coder.

In a digital mobile communication system a speech signal is coded in some manner before being channel coded and transferred to the radio path. In the GSM system, for example, digitized speech is processed in frames at intervals of about 20 ms using various methods in order to produce a parameter sequence representing speech per each frame. This information, or parameter sequence, is channel coded and sent to a transmission path. Speech coding algorithms used include RPE-LTP (Regular Pulse Excitation LPC with Long Term Prediction) and various code excited algorithms CELP (Code Excited Linear Prediction) including e.g. VSELP (Vector-Sum Excited Linear Prediction).

In addition to actual coding, following functions are also in-built into digital speech processing: a) on the transmitter side, voice activity detection (VAD) for controlling a transmitter to be switched on only when there is speech to be transmitted (Discontinuous Transmission, DTX); b) on the transmitter side, evaluation of background noise and creation of corresponding parameters, and on the receiver side, generation of comfort noise from the parameters in a decoder; and c) prevention of acoustic feedback. During a break in speech, noise makes the connection sound more pleasant than absolute silence.

In the known GSM mobile communication system, the input of a speech coder is either 13-bit PCM signals from the network or A/D converted 13-bit PCM from the audio part of a mobile terminal. The duration of a speech frame received from the output of a coder is 20 ms, the frame comprising 260 audio bits generated by coding 160 PCM coded speech samples. Out of the

parameters of a speech frame, it is the voice activity detector (VAD) that determines whether or not the frame contains speech. If speech is identified, the frames to be led to the radio path as "traffic frames" are speech frames. After a speech burst and also at certain intervals during speech breaks indicated by the VAD, the traffic frames are SID frames (Silence Descriptor) containing noise parameters, whereby a receiver may generate noise resembling the original noise out of these parameters even during the breaks.

Thus, a traffic frame contains a 260-bit speech block representing 20 ms of coded speech/data or noise. In addition, the frame comprises 56 bits available for frame synchronization, speech and data indication, timing and other information, making the total length of a traffic frame 316 bits. Said 56 bits are slightly different in traffic frames in the uplink and downlink directions.

The use of ATM technique is becoming prevalent in wired packet networks. The asynchronous transfer mode (ATM) has been developed into the transfer technique of a broadband ISDN network. In ATM data transfer, data is transferred in constant length 53-byte packets, called ATM cells. In each ATM cell five bytes constitute the cell header and the remaining 48 bytes the payload, i.e. actual information. ATM cells are specified in the recommendations CCITT Recommendation I.361 and CCITT Draft Recommendation I.150. To simplify, user data to be transferred is subdivided into fixed-length bit strings and each bit string is placed into the information field of an ATM cell. The number of bit strings per unit of time represents the transfer capacity needed by a user. In addition, a header, described in detail below, is concatenated with the information field, generating a constant length 53-bit ATM cell. An ATM cell is an independent data transfer unit as it indirectly contains information on the receiver address on the basis of which the receiver can be found in the network. Several different service criteria are defined in the ATM network, and a large number of different parameters can be set on them. Such criteria include e.g. response time, bit error ratio, and the probability of losing a packet.

ATM is a connection oriented packet network, indicating that connections are set up and terminated in accordance with standard protocols. A connection between two parties over the ATM network is called an ATM virtual channel. Among the advantages of ATM may be mentioned e.g. that various services may be offered flexibly. All bandwidths, for example, are equally natural in the ATM network within the capacity of the physical layer (by present

technique between 1.5 and 622 Mbps).

Figure 1 shows the parts of a cellular mobile communication system that are relevant to the invention. A mobile terminal (MT) communicates over the air interface Um with two radio stations 11 and 12. Here it is assumed that the mobile terminal MT is not in the vicinity of the centre point of its cell where it would only hear one radio station. The system compares the signals received by two (or more) radio stations and, based on them, makes decisions regarding handover and macrodiversity. The latter signifies that out of the signals that have passed via two transmission branches, the one that is better according to a criterion, usually the bit error ratio BER, is selected.

In a packet switched network, such as the ATM network, successive packets may be carried from the source to the destination via different routes and their propagation delays may be different. The ATM network is accessed via the UNI interface (User to Network Interface). The ATM network comprises ATM switches and transfer circuits. The ATM switches guide the packets to the destination indicated by their header. The packets carried across the ATM network on different routes are combined at a combination point 13, which may be e.g. a mobility server arranged in the network to support the mobility of mobile terminal subscribers. The combination point 13 combines the packets carried on different routes from the radio stations 11 and 12 into a common traffic stream and relays the traffic stream to the destination, which in the example in Figure 1 is a subscriber B terminal 15 connected to the local exchange (LE) 14 of a public telephone network PISN. As regards the invention, subscriber B could equally well be another mobile terminal subscriber.

Considering uplink transmission, a mobile terminal MT transfers over the air interface Um a frame F which, in the case of speech, is a speech frame, but in a general case the frame F may contain music, video signals etc. Both radio stations 11 and 12 receive the frame F and measure parameters representing the quality of the radio connection, such as signal strength and/or the bit error ratio BER.

As stated above, the payload of an ATM cell comprises 48 bytes. A full-rate speech frame in the generally used GSM system comprises 316 bits, i.e. about 40 bytes. This is relatively close to the length of an ATM cell payload. It is, however, apparent that as the number of mobile terminals increase, equipment manufacturers have to develop more efficient speech coding algorithms for compressing speech into shorter speech frames without compro-

mising quality. It is to be expected that the speech frame length in mobile terminals of the next generation could be about one fifth of the ATM cell payload.

Referring now to Figure 2, in accordance with prior art, the speech frames F are transmitted in the ATM cell payloads such that each radio station 11, 12 etc. sends a speech frame in its own ATM cell 21 to 23 and 24 to 26. The hatched portion represents an ATM cell header and the white portion the payload. Letters A, B, ... , J represent different speech frames such that the first (oldest) speech frame of the reference period is A, the next is B, etc.

A problem with the above described arrangement is variation in propagation delays when isochronous data transfer is desired after the combination of two or more traffic streams. A straightforward solution to this problem would be to buffer the traffic streams before combining them. This problem is illustrated in Figure 2 so that, owing to a longer propagation delay, the upper branch (from BTS1) is 6 packets (ATM cells or speech frames) behind the lower branch (from BTS2). The propagation delays are evened out by buffers 26 and 27 placed in front of the combination point 13. When only one packet (A) has been led across the upper branch to the buffer 26, the lower branch buffer 27 contains as many as 7 packets (A to G). Macrodiversity signifies that the combination point 13 has to choose each speech frame from the buffer 26 and 27 in which said speech frame is better according to some criterion (it has e.g. a smaller bit error ratio). Macrodiversity cannot, however, be used if it is unacceptable that the transmission is delayed (in the example of Figure 2) by six speech frames because of the higher propagation delay of the upper branch.

Another problem arises if for some reason an ATM cell is lost on the way. A straightforward solution to this problem would be retransmission, the receiver — having noticed that a cell is missing from a cell sequence — requesting that the transmitter retransmit the missing cell.

The need for buffering increases if the variation in the ATM cell propagation delays between different routes is wider than the cell intervals. Possible retransmission significantly increases the delay and thus the need for buffering.

BRIEF DESCRIPTION OF THE INVENTION

The object of the invention is to provide a method and an equipment for implementing the method so that the above problems with ATM cell

transmission can be solved. The aims of the invention are achieved with methods and systems characterized in what is stated in the independent claims. The dependent claims disclose the preferred embodiments of the invention.

The invention is based on filling the ATM cell payload, of which normally only the length of one speech frame would be utilized, with other information packets associated with the same connection. If N complete speech frames fit into the ATM cell payload, each speech frame is transmitted N times in successive ATM cells. A speech frame is sent for the first time when it is the newest speech frame of an ATM cell, and for the last time when it is the oldest speech frame of the ATM cell. According to a preferred embodiment of the invention, when a cell has been filled with as many complete speech frames as possible, that part of the ATM cell payload which still remains unused is filled with parameters describing the quality of the connection, such as signal strength and/or the bit error ratio.

It is an advantage of the method and system according to the invention that retransmission requests and retransmissions due to lost ATM cells are almost completely eliminated, leading to a smaller maximum value for the propagation delays of ATM cells. Another advantage are uniform propagation delays for ATM cells. As the invention rectifies some potential transfer errors in the ATM network and standardizes propagation delays, it allows the use of cheaper connections of a lower service class and yet retains a satisfactory quality of connection.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described below in greater detail in connection with preferred embodiments with reference to the attached drawings in which:

Figure 1 shows the relevant parts of a mobile communication network as far as the invention is concerned;

Figure 2 shows speech frame transmission in accordance with prior art;

Figure 3 shows speech frame transmission in accordance with the invention; and

Figure 4 illustrates how the arrangement according to the invention works in a situation where the ATM network loses several ATM cells.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 3, in accordance with the invention, speech frames are sent in the ATM cell payloads such that each radio station 11, 12, etc. sends a speech frame in as many successive ATM cells as a speech frame can be placed in one ATM cell. In this example, five speech frames fit into the payload of one ATM cell 31 to 36, and each radio station 11 to 12 sends each speech frame in five successive ATM cells. The example in Figure 3 shows a case in which ATM cells (34 to 36) from a lower branch (from radio station 12) are new to the buffer 27, i.e. the buffer 27 does not contain the corresponding speech frames H to N. Hence all the speech frames H to L of the ATM cell 34 to be received next are placed in the buffer 27. In contrast, the latest speech frame of the buffer 26 at an upper branch (from radio station 11) is E. The speech frames B to E of the ATM cell 31 to arrive next are already in the buffer 26 and can thus be rejected, and only the newest speech frame F of the ATM cell 31 is stored in the buffer 26.

By comparing the techniques associated with Figures 2 and 3, one can see that the arrangement according to the invention reduces the maximum size of the buffers 26 and 27 needed at the combination point 13. It is true that not much memory is saved, but if one or both subscribers are roaming and the combination point 13 has to be moved within the network, the space occupied by the previous combination point, i.e. all speech frames waiting in the buffers 26 and 27, may have to be moved, too. In addition, the need for memory is reduced by utilizing that part of an ATM cell which prior art does not utilize at all.

Figure 4 shows how an arrangement according to the invention deals with a situation in which the ATM network for some reason loses three ATM cells 41, 42, and 45, denoted in Figure 4 by a large X sign. In this example the ATM cell comprising the speech frames A to E has already been sent across the upper branch (from the radio station 11). The radio station 11 then sends the ATM cell 41 containing the speech frames B to F, followed by the ATM cell 42 containing the speech frames C to G, etc. Similarly, at the time of observation, the ATM cells 44 to 46 are approaching across the lower branch (from the radio station 12), the cells containing the speech frames A to E, B to F, and C to G, respectively. One may see that in spite of the loss of three ATM cells, each buffer 26 and 27 comprises an uninterrupted speech frame sequence, and the combination point 13 may choose from buffers 26 and 27 the

speech frame that is better according to a certain criterion — e.g. the bit error ratio BER. This comparison is denoted by a dashed line 48.

On receiving an ATM cell containing a speech frame from one of the radio stations 11 or 12, the combination point 13 cannot wait for ever for an ATM cell containing a corresponding speech frame from other radio stations. It is possible that only one radio station has heard the transmission of the mobile terminal. It is advantageous to set a maximum waiting time T which also is a maximum delay for relaying ATM cells at the combination point. If an ATM cell has been received from one radio station, and a corresponding ATM cell has not been received from other radio stations within time T from this moment, the single received ATM cell will be used.

In practice the radio stations 11 and 12, and the combination point 13 comprise a programmed digital processor, and memory; not separately shown in the Figures. Implementing the invention in practice usually involves a similar change in the software of said processor. On the transmitter side, i.e. at the radio stations 11 and 12, the change involves the transfer of the contents of a memory area corresponding to the ATM cell payload by one traffic frame such that the oldest traffic frame "drops out" and the space so created at one end of the ATM cell is filled with the newest traffic frame associated with the same radio connection. On the receiver side, i.e. at the combination point 13, the change involves separating traffic frames from received ATM cells and storing each separated traffic frame into a buffer memory. Should a corresponding traffic frame sent by the same radio station already be stored in the buffer memory, it will not be stored twice. When sending a traffic frame received from two different radio stations 11 or 12 in the direction of subscriber B, the combination point 13 chooses out of the traffic frames sent over different radio paths the one with the best parameter representing the quality of the radio connection. The bit error ratio, BER, is generally used in the comparison, but the technique according to the invention may be applied when using any parameter describing the quality of a transmission path — an air interface or a wired network.

It is obvious to those skilled in the art that with enhanced technique the basic idea of the invention may be implemented in a variety of ways. The terms and examples used are intended to illustrate but not restrict the invention. The invention and its embodiments are thus not limited to the above examples, but may vary within the scope of the claims.

CLAIMS

1. A method of transferring a transmission signal of a digital mobile communication system as packets of a packet network, the packets comprising a header and a payload, in which method

- the transmission signal is coded into parameter sequences which are placed in traffic frames;

- the traffic frames and/or parts thereof are placed in the payload of the packets;

- the packets are sent to a destination where they are received and the traffic frames are separated from their payload, and a signal corresponding to the transmission signal is restored from them;

characterized in that:

- in addition to the latest traffic frame formed, previous traffic frames, or parts thereof, of the same connection are placed in the payload of at least some packets, until the payload of the packet is essentially filled.

2. A method as claimed in claim 1, **characterized** in that parameters, preferably at least the bit error ratio, representing the quality of said connection are placed in that part of the packet payload which is not filled with traffic frames.

3. A method as claimed in claim 2, **characterized** in that in a destination receiving traffic frames sent across different transmission paths and associated with the same connection, the traffic frame is chosen that has the best parameter, preferably the bit error ratio, representing the quality of the connection.

4. A method as claimed in claim 2 or 3, **characterized** in that transmission paths comprise a radio path and at least one parameter representing the quality of the connection represents the quality of the connection on the radio path.

5. A nodal point in a digital mobile communication system, particularly a base station (11, 12) comprising means for transferring traffic frames (F) of the mobile communication system as packets (21 to 26; 31 to 36) of a packet network, the packets comprising a header and a payload, **characterized** in that the nodal point (11, 12) further comprises means for placing prior traffic frames, or parts thereof, associated with the same connection in the payload of at least some packets (31 to 36) in addition to the latest traffic

frame (A to N) formed, until the payload of the packet (31 to 36) is essentially filled.

6. A nodal point (11, 12) as claimed in claim 5, **characterized** in that it further comprises means for placing parameters representing the quality of said connection, preferably at least the bit error ratio, in that part of the payload of a packet (31 to 36) which is not filled with traffic frames (A to N).

7. A second nodal point of a digital mobile communication system, particularly a mobility server (13) comprising:

- means for receiving traffic frames (A to N) sent as packets (21 to 26; 31 to 36) of a packet network from at least one first nodal point (11, 12); and

- a buffer memory (26, 27) for storing the received traffic frames (A to N);

characterized in that the second nodal point (13) further comprises:

- means for separating from each other the traffic frames (A to N) included in the same packet (31 to 36); and

- means for storing each separated traffic frame (A to N) in the buffer memory (26, 27) unless a corresponding traffic frame (A to N) sent by the same first nodal point (11, 12) is already stored in the buffer memory (26, 27).

8. A second nodal point (13) as claimed in claim 7, **characterized** in that it further comprises means for choosing the traffic frame (A to N) with the best parameter representing the quality of the connection, preferably the bit error ratio, out of traffic frames sent by different first nodal points (11, 12) and associated with the same connection.

9. A nodal point (11 to 13) as claimed in claim 6 or 8, **characterized** in that the transmission paths comprise a radio path (Um1, Um2) and at least one parameter representing the quality of the connection represents the quality of the connection on the radio path.

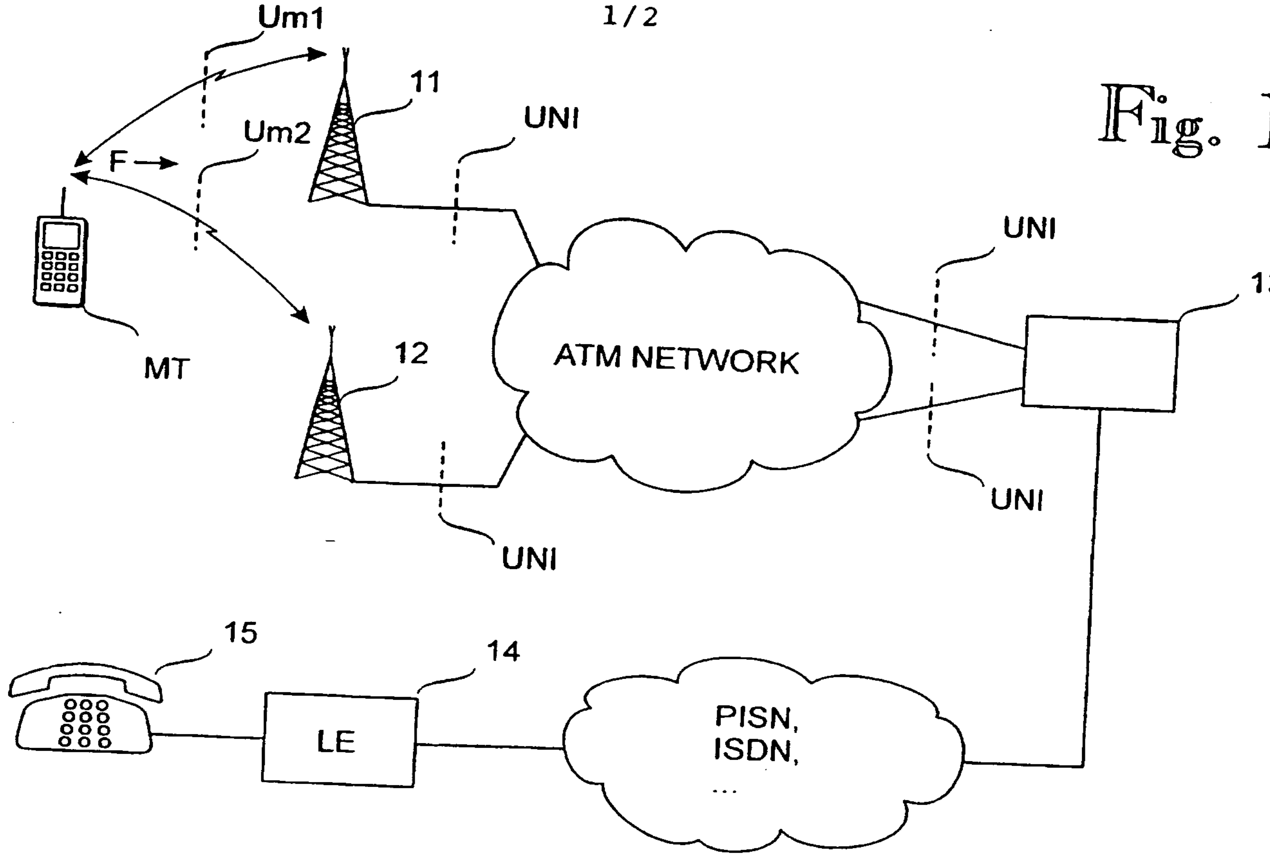


Fig. 1

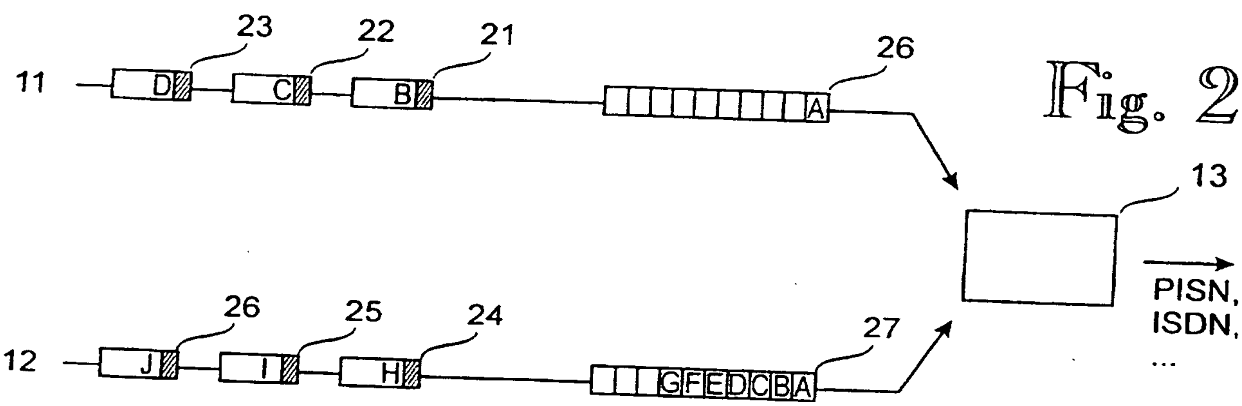


Fig. 2

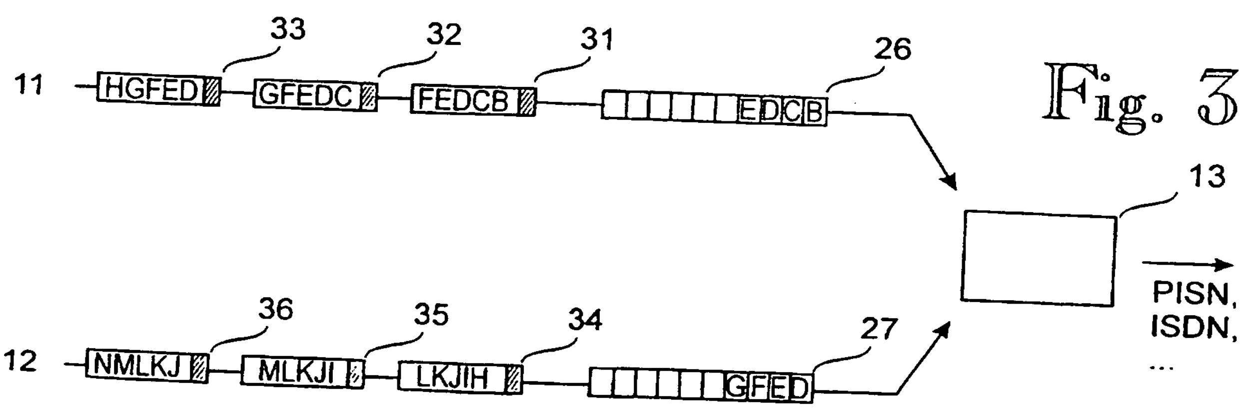
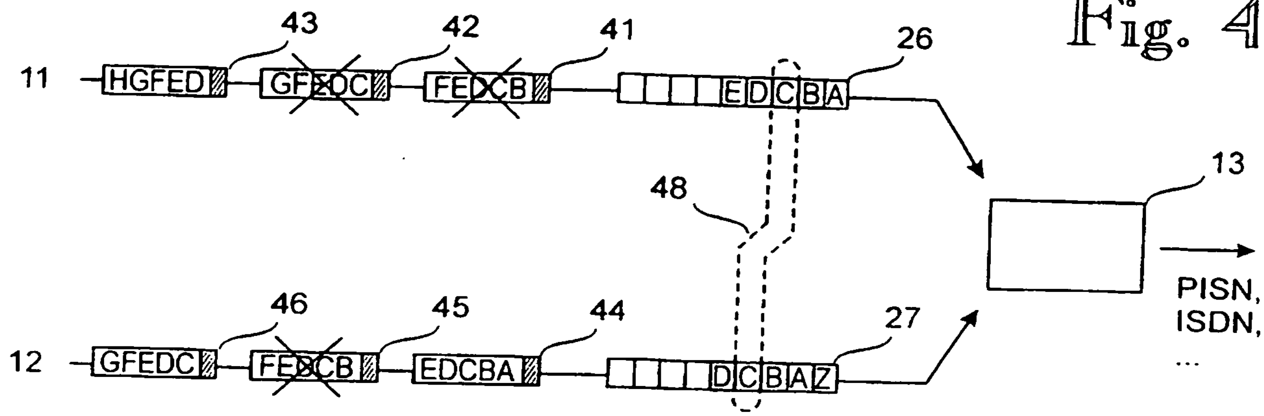


Fig. 3

Fig. 4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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 97/00473

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2288950 A (ROKE RESEARCH LIMITED), 1 November 1995 (01.11.95), page 3, line 7 - line 21; page 4, line 1 - line 23	1-6,9
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Y	WO 9212481 A1 (MOTOROLA, INC.), 23 July 1992 (23.07.92), page 1, line 23 - page 3, line 2; page 8, line 9 - page 11, line 15, abstract	1-6,9
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A	EP 0615394 A2 (NEC CORPORATION), 14 Sept 1994 (14.09.94), column 6, line 20 - column 9, line 40, abstract	1-9
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
30 January 1998	02-02-1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Peter Hedman Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 97/00473

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

07/01/98

International application No.

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